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Igazgató DR. KOCH SÁNDOR.
Publications of the Mineralogical Petrographical Institute of the University of Szeged (Hungary).

THE MINERALS OF THE SULPHIDE ORE-DEPOSITE OF NAGYBÖRZSÖNY

By S. KOCH and GY. GRASSELLY

Recent literature dealing with this mining district involves merely the work of K. Sztrókay concerning the solution of the wehrlite problem,[1] a short topography of F. Papp[2] and the interesting mining geological and genetical publications of G. Pantó.[3, 4]

At the present, only exploitation is in progress at Nagybörzsöny the lodes being only opened up to a small extent. In spite of this the material obtained provided material for interesting observations. It is anticipated that when later on the ore and non ore-minerals will be obtained more abundantly it will be possible to supplement these observations.

On the basis of the communications of G. Pantó it is known that the ore occurs in impregnated zones in highly caolinitised biotite-amfiboldacite and in its agglomeratic associated rocks, forming veins in the propylitized biotite-amfiboleandezite. According to him two orebearing phases can be differentiated. At very high temperature the main product of the first phase was pyrrhotite which was in the first place transformed still at a fairly high temperature in the second orebearing phase.

In the Middle Ages the most significant mining took place in the lodes extending at the depths of the Rózsahegy, these lodes, were opened up through the mines of Fagyosasszony, Alsó- and Felsőrózsabánya. In Moderne Times no significant mining is carried on in this district. However, the samples obtained at the recent exploitation show that Nagybörzsöny is from the genetical point of view one of the most interesting and also one of the richest mining districts of Hungary.

The ore of the lodes is compact showing only smaller cavities. The ores and the accessory minerals occured hitherto only in quite rare instances in larger overgrown crystals. The mineralassociation is abundant in species as illustrated by the following enumeration:

The oldest minerals:	apatite, quartz, pyrite I., galena I., pyrrhotite, valleriite, sphalerite I., chalcopyrite,
younger minerals, partly formed from the material of the older ones:	arsenopyrite, tetrahedrite, native bismuth, bismuthinite, native gold, galena II., cosalite, sphalerite II., jamesonite,

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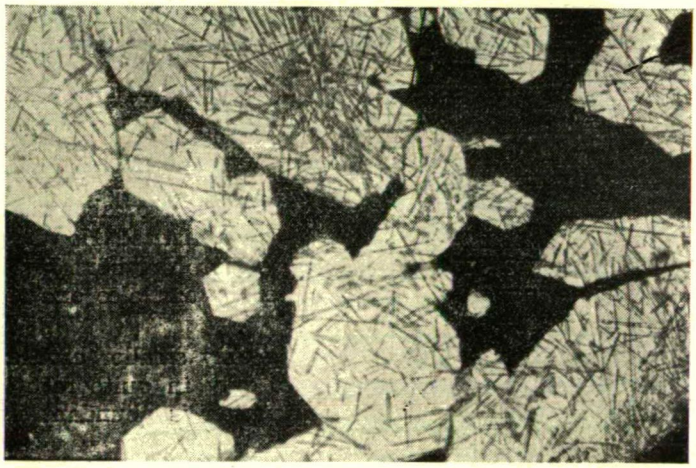
semseyite, tetradymite, (csiklovaite, hessite, petzite, argentite, proustite, molybdenite) barite, dolomite, calcite,

the minerals of the oxidized zone: hydropyrite-melnikovitepyrite-pyrite II., marcasite, siderite, magnetite, cronstedtite, chalcocite, covellite, goethite, limonite, arsenolite.

The minerals enumerated in brackets were found by the above authors, however, those of the present paper could not detect them in their polished sections.

Apatite

Apatite is the oldest mineral of the impregnated zones. It occurs as inclusions in quartz and the oldest ores in the form of fine needles in pneumatolytic hollows of vulcanic rocks and not in the according to *c* tabular overgrown crystals occurring only rarely in hydrothermal lodes (Roznava). A crystalline quartz sample obtained from the immediate vicinity of the apatite content of the ore calculated on the basis of the determination of the P_2O_5 content amounted to 0,59 per cent. In this crystalline quartz the apatite needles are arranged spherolytically, whereas in the crystallized quartz and ores its thin needle crystals can be detected arbitrarily scattered, or aggregated in larger numbers (microphoto 1.). Of the primarily separated ores pyrrhotite

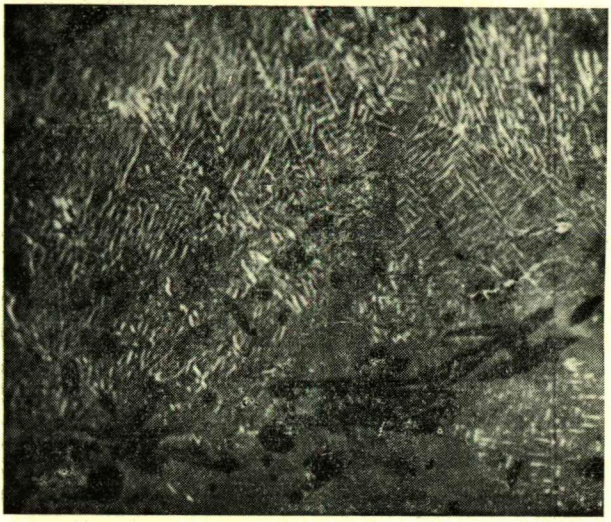


1.

Thin acicular crystals of apatite in crystallized quartz. 380 ×, N ||

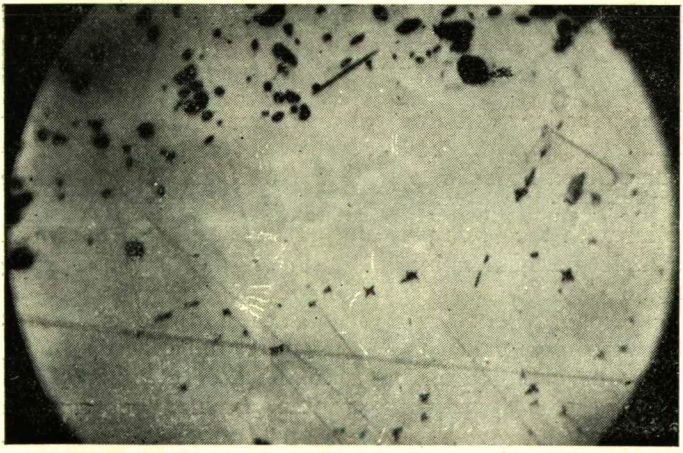
most probably also contained apatite but after the transformation of the sulphide the apatite needles could no more be detected. The presence of apatite in sphalerite and chalcopyrite is a very interesting phenomenon. The small apatite needles contained in sphalerite were detected associated with a dismixtured chalcopyrite lamellae system (microphoto 2.) and those contained in chalcopyrite associated with tiny sphalerite stars (microphoto

3.). In arsenopyrite the ore surrounding the quartz crystals is crowded with fine apatite needles. The occurrence of apatite in these ores points to them being formed at an unusually high temperature.



2.

Apatite needles in sphalerite with dismixtured lamellated system of chalcopyrite.
Oel imm. 450. ×, N ||



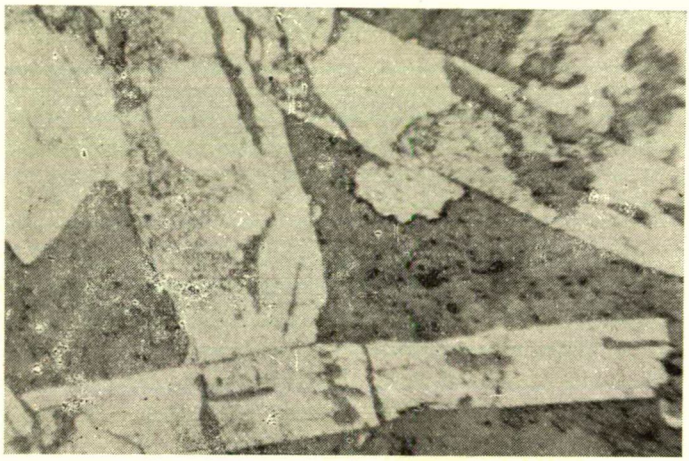
3.

Apatite needles in chalcopyrite with spalerite stars.
Oel imm. 450 ×, N ||

Pyrrhotite and the minerals formed from it

Of the once dominating ore — pyrrhotite — only fragments containing either syngenetic or somewhat older idiomorph, but strongly corroded hexa-

hedral crystals of the first generation of pyrite can be found. In comparison to the dominating pyrrhotite the amount of pyrite must have already originally been slight. In addition to pyrite the rounded or elongated oval inclusions of galena I. could also be detected in pyrrhotite. Rendering it probable that this ore had still had an older generation formed in the early stages of ore--formation. The mostly alterated pyrrhotite has a lamellar tabulated structure. Its roselike aggregates formed by parallel intergrowths of some welldeveloped finely tabulated crystals a few mm in size are overgrown on the walls of the small hollows of the ore. The pyrite pseudomorphoses a few cm in size contained in the collection of the Hungarian Geological Institute prove that pyrrhotite also occurred in larger crystals.



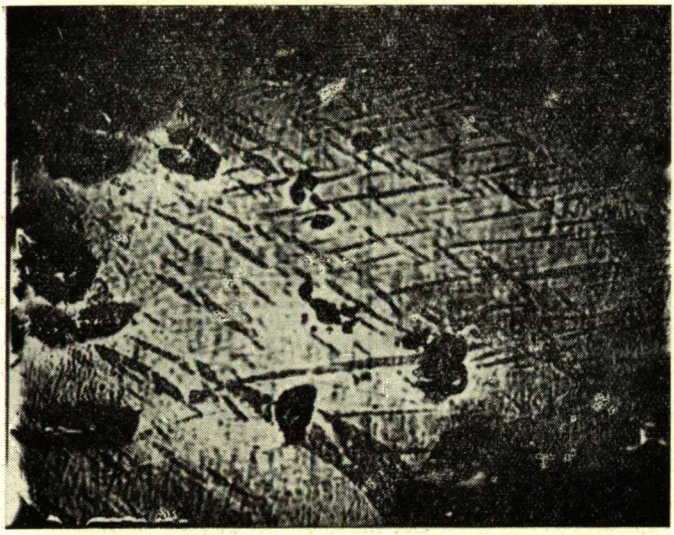
4.

Pyritized pyrrhotite lamellae. 200 ×, N ||

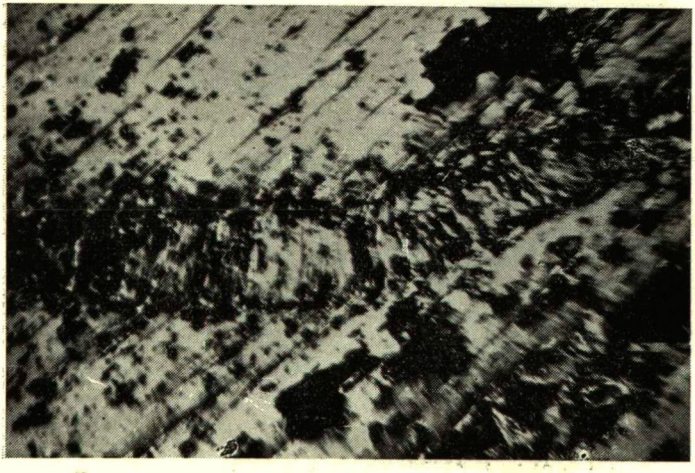
Our polished sections contained a great number of lamellae and lamellated pyrrhotite aggregates one mm in size, partly or quite transformed into pyrite and surrounded by siderite (microphoto 4.). In the lamellae numerous thin long spindleformed ingrowths of the „light" component — often running parallel with the basis platelets — could be detected. On air etching a pyrrhotite sample permeated by gelpyrite showed an interesting structure (microphoto 5.).

The dark coloured platelets arranged according to definite crystallographical directions corresponded to the „lighter" component, the presence of which could also be observed on the sample before etching. A translatio phenomenon observed on a pyrrhotite granule polished perpendicularly to the basis showing a lamellar structure was most interesting. Among the strongly curved pyrrhotite lamellae products of the alteration could already be detected (microphoto 6.). It deemed of no interest to analyse this pyrrhotite as even its smallest granule was not homogenous, however, it could be established that it did not even contain in spectroscopically detectable traces nickel. An analysis of the metal content of a sample collected from the waste tip of Alsó-Rózsabánya containing mainly iron-sulphides and rich in ore shows the following results:

Fe	46,19%
Cu	1,97
As	4,85
Zn	2,00
Pb	traces



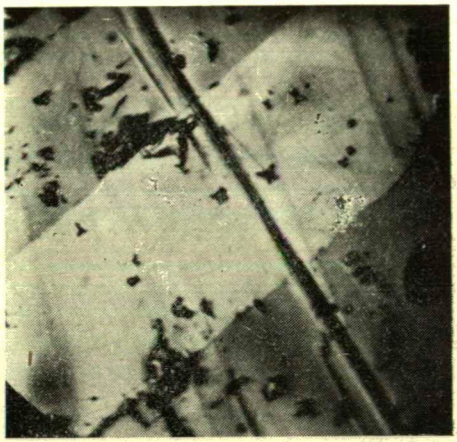
5.
Etching figures on pyrrhotite performed by air etching. Oel imm. 400 ×, N ||



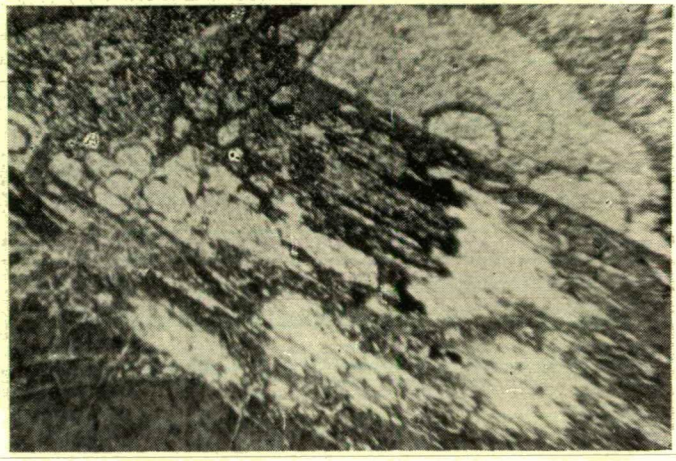
6.
Translation of pyrrhotite lamella, perpendicular to the plate (0001). 200 ×, N ||

Of the ores syngenetic with pyrrhotite both sphalerite and chalcopyrite play a role in replacing it. Pyrrhotite is lamellarly replaced by chalcopyrite in which sphalerite stars can be detected (microphoto 7.). The readily

decomposing pyrrhotite is interwoven and surrounded at the border of the granules along the cleavage direction by the iron-sulphides formed from it in the oxidized zone (microphoto 8.). These secondary ores have a gel structure which varies considerably, at numerous sites fine bird eyes can be



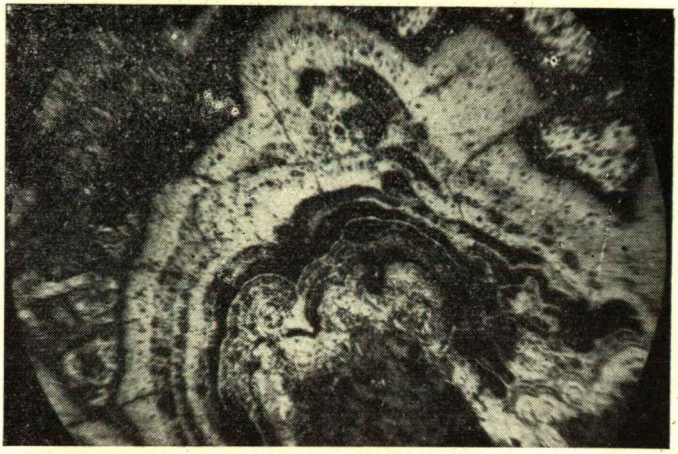
7.
Chalcopyrite replacing pyrrhotite with sphalerite stars.
Oel imm. 400 ×, N ||



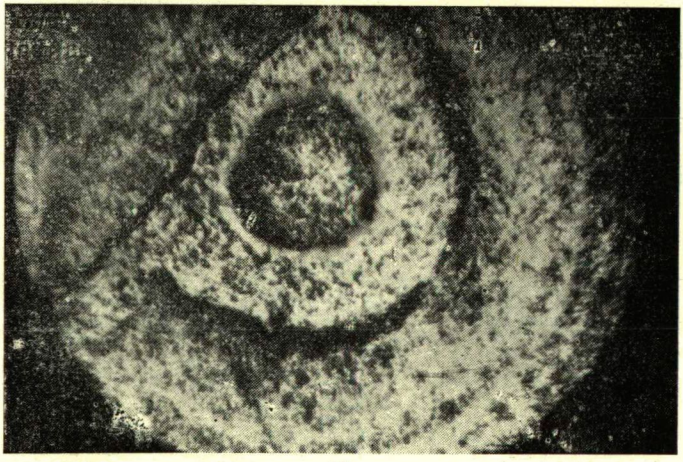
8.
Pyrrhotite lamella replaced by secondary iron-sulphides. 160 ×, N ||

discovered (microphoto 9.). In the pyrrhotite as well as in the gel the „intermediate product" mentioned by Ramdohr showing a strikingly strong interference phenomenon could be detected. This „intermediate product" extended in the cleavage direction of the pyrrhotite in thin bands, or it could be found as small patches in the gel.

Among the alteration products the very compact, badly polishable very finely granulated hydropyrite showing between crossed nicols a quite dark colour, melnikovitepyrite with a varying gel structure and the finely granulated pyrite in which exquisite bird eyes could be found occurred (m i c r o-



9.
Gel structure in secondary iron-sulphides. 200 ×, N ||



10.
Birds eye structure. 200 ×, N ||

b h o t o 10.). These intermediate products lead to the formation of the coarsely granulated pyrite II. and marcasite surrounding often the latter at the border of its crystal aggregates, but sometimes also penetrating into it.

The intermediate products ranging between $FeS - FeS_2$ are so much interwoven that it is very difficult to select even grossly homogeneous samples for chemical investigations. The filtrate of an on the whole homogeneous dark grey colour compact hydropyrite sample treated for ten minutes with N hydrochloric acid contained:

12,91 per cent Fe
3,13 per cent SO_4.

An analysis of the residual substance after the treatment showed the following composition:

Fe	27,94%
Cu	0,90
As	3,15
Mn	0,13
Sb	trace
Co	0,01
S	32,44
Al_2O_3	3,55
CaO	0,81
MgO	0,48
insol. residue	0,02

Recalculating the sulphated iron-sulphide amount for sulphide merely taking the component elements of the sulphides into consideration and then calculating the results for 100 per cent:

Fe	52,04%
Cu	1,14
Mn	0,16
Co	0,01
As	4,01
S	42,64
	100,00%

Subtracting from the result the amount of iron and sulphur needed for the formation of chalcopyrite and arsenopyrite, as well as that of sulphur treatment with hydrochloric acid we obtain:

Fe	48,06	0,8607	1
S	39,78	1,2403	1,44

thus the iron-sulphur relation is: Fe : S = 1 : 1,44.

On calculating for 100 per cent the residual substance gained after the treament with hydrochloric acid we obtain:

Fe	27,94%	43,28%
Cu	0,90	1,39
Mn	0,13	0,20
Co	0,01	0.01
As	3,15	4,87
S	32,44	50,25
		100,00%

and again subtracting the iron and sulphur amount needed for the formation of the above minerals the iron-sulphur ratio of the residual substance is:

$$Fe : S = 1 : 2,11$$

Thus in the course of the transformation the iron amount decreases and on the decomposition of the pyrrhotite lattice the iron evolving from the pyrrhotite lattice the iron evolving from the compound partly forms arsenopyrite, the greater part, however, is transformed into siderite interweaving densly the intermediary products. The crystals and crystalline aggregates of pyrite II. can be found embedded.

As already pointed out by G. Pantó in the course of decomposition a part of the iron content of pyrrhotite was taken up the younger arsenopyrite partly formed from it. The small idiomorph crystals and crystal aggregates of the latter crystallising readily can be found in the intermediate products mentioned above, less frequently they replace pyrrhotite lamellarly. In some sections its idiomorph crystals are surrounded by the crystal aggregates of the younger marcasite. Among crystal overgrowths, arsenopyrite is the most frequent ore, its crystals attain half a cm in size. The crystals are short columns plane forms (110), (101) and (001) could be detected on them. Very frequently parallel intergrowths in the *b* crystallographic axis direction, as well as sections with very fine twinned intergrowths according to (110) could be observed. Each of our electrographically etched polished sections showed the zone structure of arsenopyrite crystals. An analysis of the crystal overgrowths did not demonstrate any cobalt, however, this element could be found both electrographically and analytically in the crystalline granular aggregates, but always only in the younger crystal granules situated at the border of the aggregate. The crystalline granular aggregates also contained nickel in traces. Pyrrhotite less frequently sphalerite, are replaced by arsenopyrite, whereas pyrite II. inturn replaces the latter. Very fine pyrite pseudomorphoses after arsenopyrite could be found in the polished sections. An analysis of crystallised arsenopyrite is as follows:

Fe	33,09%
Mn	0,20
As	40,93
S	20,06
insol. residue	5,85
	100,13%

The fine small crystal overgrowths of siderite, a few mm in size, also formed from the iron contained in the pyrrhotite can be found in the oxidized zone in every polished section filling up the hollows and penetrating into the fissures of the ores. On the small crystals in our possession the following crystalforms could be established by goniometric measuring (according to order of magnitude):

$$(21\bar{3}1)\ (11\bar{2}0)\ (05\bar{5}1)\ (0001)\ (10\bar{1}1)\ (02\bar{2}1)\ (01\bar{1}2).$$

The greater part of the crystals show a scalenohedral habitus, beside the dominating $(21\bar{3}1)$, the small planes $(11\bar{2}0)$, $(10\bar{1}1)$, $(02\bar{2}1)$ and $(01\bar{1}2)$ could also be found. The minute crystals on which only planes $-1/2\ R$ can be detected are rarer they have a saddlelike curvature. The crystals of the third type, one mm in size, are more thickly tabulated according to (0001) and in addition to the dominating basis planes planes $(21\bar{3}1)$, $(11\bar{2}0)$ and $(05\bar{5}1)$ can also be detected, on them the minute crystals form irregular intergrown aggregates. All three types are also known from Kisbánya (Herja, Roumania). The siderite of Börzsöny corresponds almost exactly as regards crystal form as well as composition to that found in Kisbánya of similar origin.[6]

	Nagybörzsöny	Kisbánya	Calculated
FeO	61,07%	61,68%	62,01%
MnO	0,76	0,14	—
CaO	trace	0,08	—
MgO	trace	0,23	—
CO_2	37,88	37,80	37,99
residue insol.	0,48	0,31	—
	100,19%	100,24%	100,00%

As can be seen the composition of both these siderites is very similar to the theoretical one. It is anticipated that as the mining proceeds larger and finer samples of this interesting mineral will be available.

J. Erdélyi was the first to observe the crystal aggregates of cronstedtite on a sample collected from the waste tip of Alsórózsabánya. The crystal aggregates were 1 mm, the crystals composing then still smaller, hardly 1 mm in size. On one sample belonging to the Geological Institute we also detected this phenomenon. We detected — also only on a single sample — a magnetite aggregate composed of minute octahedral crystals. According to Ramdohr at the transformation of pyrrhotite — pyrite, magnetite formed in the following way:

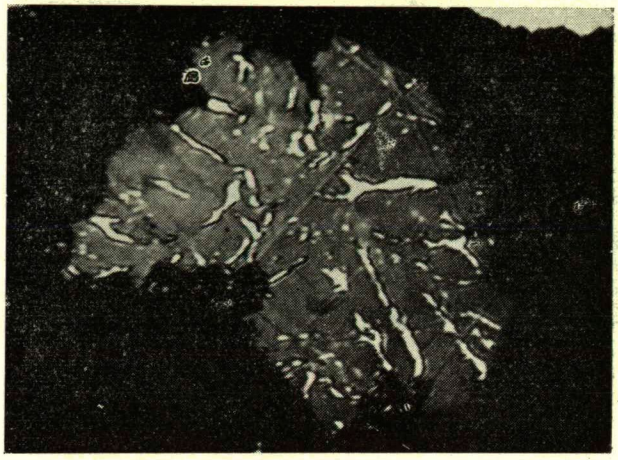
$$6\ FeS + 2\ O_2 = Fe_3O_4 + 3\ FeS_2$$

The dark brown velvetlike globules hardly one mm in size of needle iron ore consisting of fine threads could be observed as overgrowths on pyrite II. The surface of the disintegrated pyrite fragments is coated with ochreous limonite.

Sphalerite

The sphalerite of Nagybörzsöny is like that of Kisbánya black and rich in iron. The internal reflexes demonstrated on polished sections have a red-brown — reddish colour. The well developed crystals one mm in size showing a crystalline granular structure can usually be detected overgrown on the walls of the hollows of the ore fragments or intergrown in the carbonateous basic substance. In the former platelet forms (111), ($1\bar{1}1$), (100) could be found, platelets (111) dominating the greater part of the crystals are twins. The intergrown crystals show the same combinations of form, but the inverse tetrahedron and the hexahedron only can be observed in hardly detectable thin small bands. The sphalerite formed at very high temperature contains not unfrequently badly corroded remnants of older pyrite and pyrrhotite. These sphalerites are particularly rich in dismixtured products. The replaced pyrrhotite remains are lamellar, angular, whereas the pyrrhotite inclusions formed in the course of the dismixture are droplike, there order of magnitude being far below that of the replaced pyrrhotite fragments. In some of the chalcopyrite granules formed at the dismixture the plates and patches of valleriite are most conspicious indicating that the chalcopyrite — valleriite system formed at a high temperature — unusual in the case of ore lodes of hydrothermal origin — and that its substance was originally chalcopyrrhotite, the two ores having formed at its dismixture. Valleriite contained irregularly or as plates in larger chalcopyrite granules and in smaller ones vermiform is very striking by virtue of its strong pleochroismus and its illuminating interference colours bet-

ween crossed nicols (microphoto 11.). Valeriite was detected by Helke[7] under quite similar conditions in Kisbánya (Herja), as well as by the present writers on their own preparations.

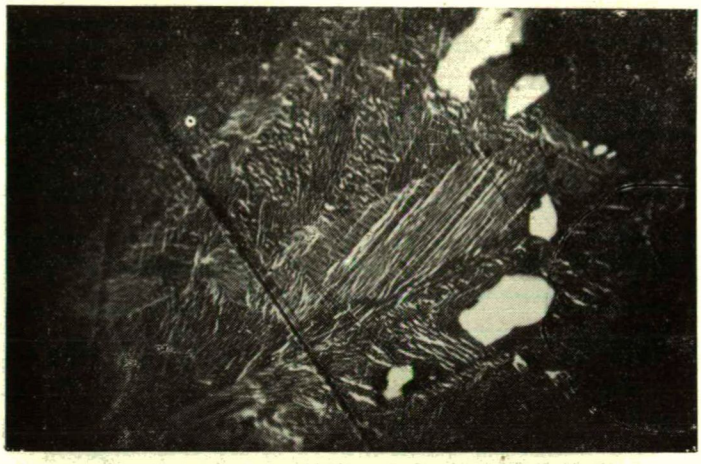


11.

Valleriite in sphalerite grain. Oel imm. 800 ×, N ||

The sphalerite-chalcopyrite systems vary extremely. There is hardly a sphalerite in which a chalcopyrite inclusion cannot be found. The inclusions can mostly be detected on the borders of its crystal aggregates towards the middle they are far less frequent. It is interesting that at the points where sphalerite comes into contact with other sulphide ores chalcopyrite inclusions can be found in large numbers at the dividing line of the two ores. The chalcopyrite droplets of a few microns of order of magnitude undoubtedly produced by the dismixture, can often be found associated with plate systems usually divided according to crystallographic directions, the chalcopyrite substance of which extending according to crystallographic directions and also sometimes indicating the polysynthetic twin structure of the sphalerite can partly be interpreted by replacement (microphoto 12.) and partly by simultaneous separation or by oriented intergrowths. The repeated finding of chalcopyrite rows in marked zones in various sections seems to support the latter assumption. The inclusion systems cannot only be detected under the microscope, but also often with the naked eye, frequent by attain the size of one mm the different bands vary from 25—30 microns and those not attaining the microscopic field of vision. The photos are very much the same as those described by G. Pantó[8] of the sphalerites of the Mihály lode of Toroiaga, the only difference being that they vary to a far greater extent.

The small tetrahedral sphalerite crystals ingrown in the carbonateous quartzous substance also contain abundantly chalcopyrite inclusions, however, their iron content is already considerably less, as indicating the following analyses:



12.

Chalcopyrite lamellae system in sphalerite.
Oel imm. 600 ×, N ||

	crystalline granular sphalerit overgrowths	the sulphide part calculated for 100 per cent	ingrown sphalerite crystals
Zn	44,88%	48,45%	52,58%
Fe	14,71	15,87	11,51
Mn	1,01	1,09	1,19
Cu	0,37	0,39	0,53
S	31,68	34,20	32,72
CaO	2,43		
MgO	0,75		
CO_2	2.72		
insol. residue	1,23		
	99,78%	100,00%	99,73%

Spectroscopycally Cd could be detected in traces in the ingrown sphalerite crystals.

In our polished sections we detected in addition to these two sphalerites which are inspite of the divergence of their composition and appearance undoubtedly syngenetic, another very interesting sphalerite of younger origin. First we noticed a little tetrahedral crystal contained as inclusion in the pyrrhotite. On the basis of its reflection capacity as well as its internal reflexes it could be only assumed to be a sphalerite, however, on examination between crossed nicols the mineral showed marked dark bluish — dirty violetlike interference colours, thus behaving like an anisotrope. Subsequently we found in some of our polished sections this sphalerite overgrown on pyrite crystals or older isotrop sphalerite granules, or ingrown in siderite as radial needles forming crystal groups resembling the „Schalenblende" entities (m i c r o p h o t o 13.). In crystalgroups of the sphalerite, formed from acid solutions in the course of the later ore forming phase and pseudomorph after wurtzite, overgrown on the older sphalerite is became immediately conspicuous that the colour of our mineral was somewhat darker (more bluish) than that of

the older sphalerite. Owing to its crystal needles being appreciably thinner than the granules of sphalerite its internal reflexes were far more numerous and showed a lighter colour. In each sample the anizotropic behaviour is striking. Ramdohr mentions that sphalerites containing a copious amount of iron might be anizotrope, however, it is open to question why only the crystals of this younger generation are anizotrope. Owing to the minute size of the needle aggregates and their small number this sphalerite could not be analysed. It should still be mentioned that in this anizotrope sphalerite chalcopyrite inclusion could not be detected.

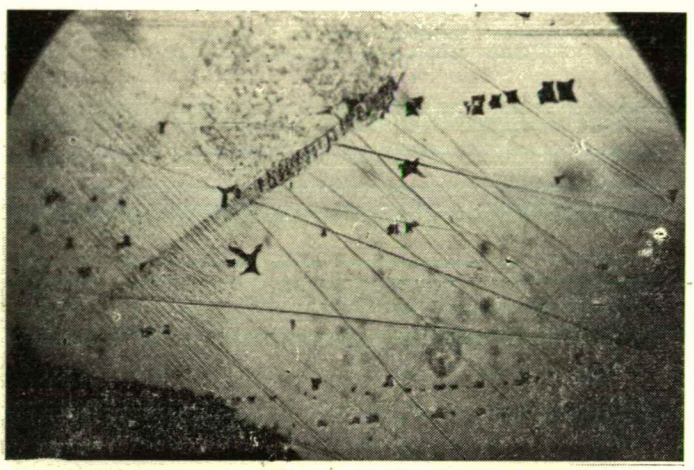
13.

Acicular radiated crystal group of secondary, anisotrope sphalerite. Oel imm. 400 ×, N ||

Chalcopyrite

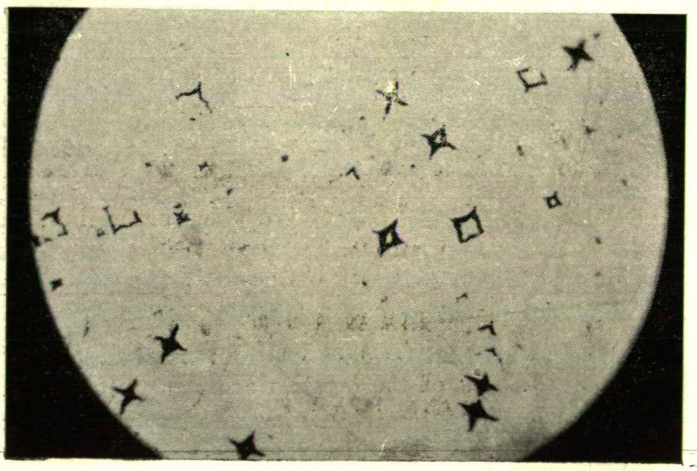
Chalcopyrite is the fourth member of the older ore formation. Quantitatively it is far less significant than pyrrhotite and sphalerite. In the samples collected in the waste tip of Alsórózsabánya it was crystallized and associated with arsenopyrite as overgrowths on rock lodes. The crystals are pseudotetrahedrons 5—6 mm in size, forms (111) and ($1\bar{1}1$) developed approximately to the same extent. The surfaces of the crystals are coated by orientedly overgrown sphalerite. Sphalerite plates (111) intergrew hypoparallel according to this plane planes ($1\bar{1}1$) were composed of numerous minute crystals. On examining them in polished sections it could be observed that the chalcopyrite crystals contained many strongly corroded pyrite granules and were crowded at certain points with sphalerite „stars" migrating from the border, the sphalerite cortex, towards the interior, whereas sphalerite contained the granular lamellar chalcopyrite remnants as shown on microphoto 14. Thus the two syngenetic ores mutually replace each other at the border of the chalcopyrite crystals.

The always xenomorphous granules of the massive chalcopyrite show a fine twin-lamellar structure and in each granule the sphalerite stars characteristic of chalcopyrites formed at high temperature, also mentioned by Pantó[3] from this provenance can be detected. Some granules showed a whole



14.

Chalcopyrite with sphalerite «stars» migrating into its interior. Oel imm. 500 ×, N ||

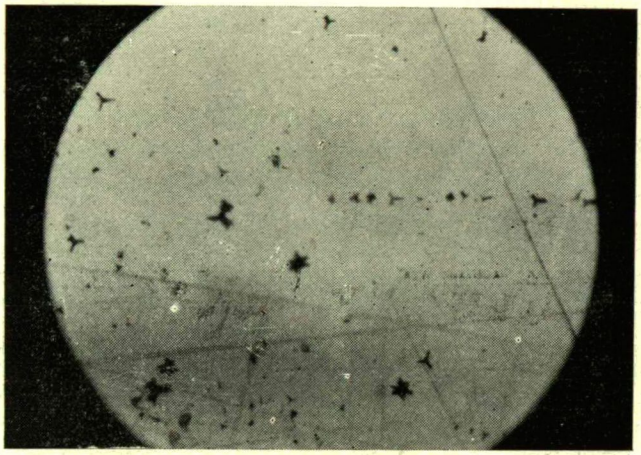


15.

Sphalerite stars in chalcopyrite. Oel imm. 600 ×, N ||

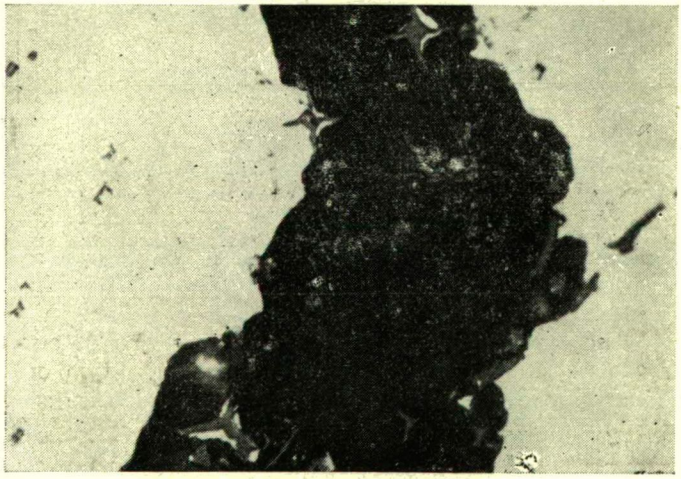
star collection (microphoto 15.). The size of the stars ranges from a few microns to a size hardly visualable at 1200 magnification. Their shape varies too. Usually, the polished sections are perpendicular to the diagonal axis, the stars have four branches. Less frequently the stars are perpendicular to the trigonal axis in the polished sections, they have three and in the case of twins-

six branches (microphoto 16.). Part of the stars are composed of pure sphalerite, in others in the middle of the sphalerite star a to a greater or lesser extent replaced chalcopyrite nucleus can be detected. In some chalcopyrite crystal granules the sphalerite stars extend along the chalco-



16.

Sphalerite stars, the section is perpendicular to the axis of trigonal. Oel imm. 500 × N ||

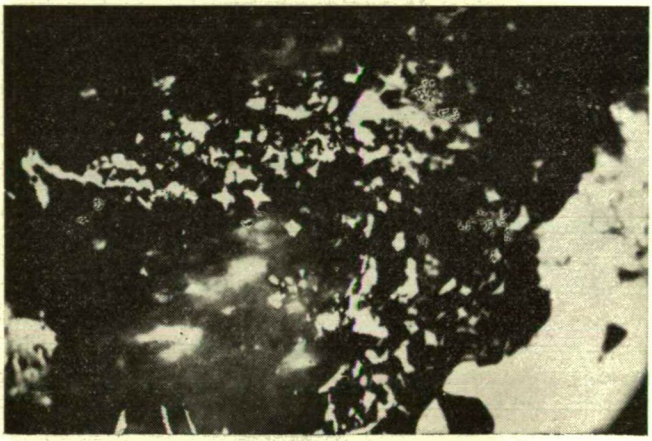


17.

Sphalerite stars in siderite replacing chalcopyrite with rests of the latter. Oel imm. 800 ×, N ||

pyrite twin lamellae in straight parallel rows. If siderite replaces chalcopyrite on the borders of the sphalerite stars a small amount of chalcopyrite can still be found as sphalerite is more difficultly replaced than chalcopyrite (microphoto 17.).

Helke[7] found similar stars in the chalcopyrite of Kisbánya (Roumania), whereas the present writers detected some in the chalcopyrite of Oradna (Roumania), however, in no place were they so abundant and various as in Nagybörzsöny. An interesting phenomenon was the detection of a chalcopyrite dismixture in the sphalerite crystals surrounded by chalcopyrite, whilst chalcopyrite — on the other hand — contained sphalerite stars. This structure supports convincingly the assumption that the two ores formed syngenetically at very high temperature. Our chalcopyrites contain, in addition to the stars, numerous somewhat larger, rounded, droplike, or irregularly outlined sphalerite inclusions 25—35 micron in size, apparently also the products of dismixture. In our polished sections sphalerite is in many places replaced by siderite. The sphalerite replaced by siderite assumes sometimes the shape of a star in the replacing carbonate (microphoto 18.). These „stars"



18.

Sphalerite «stars» forming by means of resorption in the replacing siderite. Oel imm. 400 ×, N ||

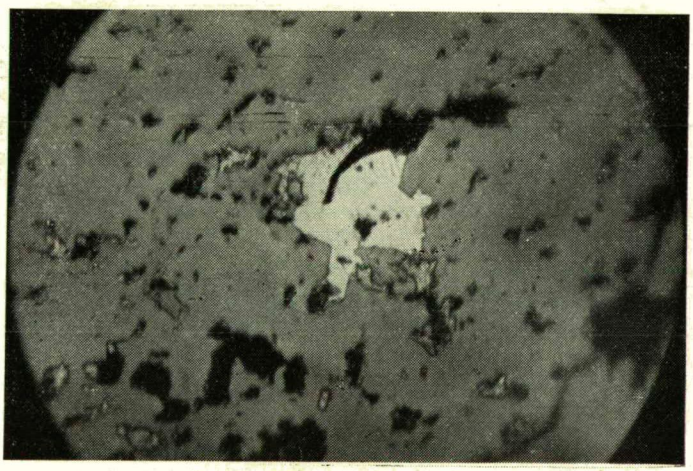
are identical formations to those observed in the chalcopyrite and mentioned above with respect to the orientedly intergrown chalcopyrite-sphalerite system. In both cases the „stars" are products of resorbtion which, in spite of their resemblance to the crystal germs due to dismixture, are of exactly opposite origin as they form at the dissolution of sphalerite. In two our sections in addition to chalcopyrite the minute granules of chalcocite surrounded by covellite platelets could also be detected.

Bismuth ores, native gold

G. Pantó collected several interesting samples of the material of the new exploitations in the surroundings of the pit of Rózsabánya. He examined them and gave us some for our investigations. It could be established that the ore is arsenopyrite and that it is very like the glaukodote termed „alloclase" which can be found in the white limestone of Erzsébetbánya in Oravicabánya (Roumania) and which also contains bismuth. Similarly to glaucodote the arsenopyrite from Rózsabánya is also impregnated in a spongelike manner with

patches varying in size and containing bismuth minerals. Our polished sections contain besides bismuth minerals younger than arsenopyrite also older pyrite and chalcopyrite which are replaced by arsenopyrite. The chalcopyrite is crowded with sphalerite stars. The bismuth ores replacing chalcopyrite, in the first place bismuthinite, absorb the latter and accumulate the less soluble sphalerite remnants at the border of the two ores.

Among the bismuth minerals filling out the pores of arsenopyrite and thus replacing it, native bismuth is the oldest. Its amount is significant, the granules are rounded, droplike and beside the white arsenopyrite they seem to have a reddish colour, the charasteristic twin lamellae very visible on them. In the analysed sample the amount of native bismuth was 11 per cent. Apart from bismuth, bismuthinite is the most frequent bismuth ore. Beside arsenopyrite bismuthinite has always a slightly bluish grey tint, its reflexion capacity is weak, the reflexion pleochroizmus can be instantaneously observed, the interference colours are striking and depend upon the orientation. Its characteristic thin, columnar, muddled, aggregates can be found in the smaller hollows or on the border of arsenopyrite, in which case the minute, fine crystal needles are overgrown on its crystalline mass. Cosalite can be found in the vicinity of native bismuth replacing it. Beside arsenopyrite it seems to have a light greyish colour its reflexion capacity is weaker, it does not show any pleochroismus the interference colours are not bright. It has a granular structure. Microchemical examinations showed in addition to bismuth also lead. It may be that part of the silver is also bound to this ore.



18.

Native bismuth (light grey), native gold (white) in arsenopyrite (dark grey). Oel imm. 450 ×, N ||

In one of our polished sections a bismuthtelluride of the provenance, most probably tetradymite, could also be identified. Beside arsenopyrite its colour is light cream. It possesses the splendid cleavage surface characteristic minerals with a layer-lattice, as well as a strong reflexion capacity, its interference colours are identical with those of the tetradymite from Csiklova (Roumania). Tellur, detected in traces in the analysis, is also contained in it.

In addition to the bismuth minerals — through far less frequently — jamesonite can also be found in the hollows of arsenopyrite. The reflexion of its columnar crystal nedles is weaker and a little more greyish than that of arsenopyrite and shows a light greenish tint. Reflexion pleochroismus is charasteristic.

Beside the bismuth-ores, in the first place beside native bismuth, the irregular platelets of native gold, a few microns in size, could be detected (microphoto 19.). The lighter colour indicates its silver content. According to the analysis of Csajághy[3] the gold content was 204 gr/t, thus it occurs as free gold in this ore.

Analyses of this strange arsenopyrite ore, replaced by bismuth-ores, were made by Csajághy as well as by the present writers. The results are approximately corresponding (calculated for 100 per cent).

	Csajághy	Writers
Fe	23,62%	24,87%
Co	0,12	0,27
Zn	0,04	—
Pb	3.93	4,31
Cu	0,24	0,22
As	30,96	30,34
Bi	21,44	21,62
Sb	0,33	0,73
Te	—	trace
S	19.32	17.64
	100,00%	100,00%

(It is deemed of interest to mention that the bismuth content of the „alloclase" of Oravicabánya ranged between 22,96—32,83 per cent.)

The significant amount of iron is in first place the component of arsenopyrite, pyrite, chalcopyrite and jamenosite; cobalt is that of arsenopyrite, zinc that of sphalerite, which could not be detected in our polished sections; lead, that of cosalite and jamesonite; copper that of chalcopyrite; arsenic that of arsenopyrite; bismuth that of native bismuth, bismuthinite, cosalite and tetradymite-traces; tellur that of the latter; and finally antimony that of jamesonite.

Bismuthinite needles penetrate into the hollows of the sampies overgrown on crystallized arsenopyrite. The aggregate of the extremely fine silky lustreous crystal aggregates of arsenolite coat the ores mentioned above. The arsenic they contained could be demonstrated by chemical analysis. Usually, thus also within the Carpathian mountain range, bismuth and its minerals, save for very rare bismuth tellurides, can only be found in hardly detectable traces in sulphide ore occurrences bound to vulcanic rocks of the young Tertiär period (Recsk, Kapnikbánya, Felsőbánya, Kisbánya). The occurrence of this element and its minerals, foreign to the mineral-associations of this lode, produces a specific mixed lodetype characteristic for Nagybörzsöny.

Galena II. and lead—antimony ores

The occurrence of the galena II., more copious than that of galena I., is bound to the ore of the Fagyosasszony lode. It replaces pyrrhotite, sphalerite, chalcopyrite, the former often lamellarly. If it is associated with the harder ores it gets polished and is full of characteristic triangular cleavages. Along

its cleavage it gets cerussitized. The small amount of jamesonite and the very uncommon semseyite associated with it are formed from it. The irregularly intergrown needle aggregates of jamesonite extending centripetally from the border of the crystals and crystal aggregates of galena occurred more frequently. Among the needles crystal twins are very common. The reflexion pleochroismus is conspicious as is beside the izotrope galena the anizotropy. The characteristic fanlike group of lamellar crystals of semseyite occurring far less frequently could merely be detected as crystal groups in two sections can be found embedded in the carbonate, coating the galena. It did not show reflexion pleochroismus, the whole crystal group was hardly one mm in size, however, between crossed nicols it showed the pinkishgreyish anizotropy characteristing the semseyite occurring in Kisbánya with which it was compared. Microchemically lead and antimony could be demonstrated in the semseyite granules. Apparently semseyite, of which alone in the mining district of Szatmár four provenances are known, occurs if also only scarcely, in other as yet unknown mining districts. Antimony could not be detected, the slight amount of antimony contained in the analysed ore samples is bound to these two lead-antimony-sulphides.

Of the few associated minerals barite, found in the lower adit, was interesting. Its crystals are thin and columnar, a few mm in size, they occur associated with pyrite and are partly coated by calcite, they extend in the direction of crystallographic axis a and only show lustreous curved platelets according to (011). Their terminal platelets are either covered by an entirely curved plate or they fray out. The fine crystalline quartz, having in the older generation apatite inclusions, furthermore the zonal structured dolomite, curved in a lentiform manner, sometimes showing a red colour, its crystals often being replaced by siderite and finally the white calcite overgrown $-1/2R$ small crystals with curved planes on the walls of the little hollows, should still be mentioned.

CONCLUSIONS

In the Carpathians there are still two other hydrothermal ore-occurrences bound to young vulcanic rocks and formed at a similar high temperature as those of our mining districts: Oradna (Rodne-Veche, Roumania) and Kisbánya (Herja, Roumania) also mentioned by Pantó.

Pyrrhotite was the primarily dominating ore in all three provenances. Valleriite does not only occur in Kisbánya, but also in Nagybörzsöny. The sphalerite of all three provenances is strikingly rich in iron. The chalcopyrite of all three provenances contains sphalerite stars. The principal ore minerals of all the three are the same:

Nagybörzsöny	Kisbánya (Herja)	Oradna (Rodna-Veche)
pyrrhotite	pyrrhotite	pyrrhotite
sphalerite (15, 87% Fe)	sphalerite (14, 69% Fe)	sphalerite (14, 27% Fe)
chalcopyrite	chalcopyrite	chalcopyrite
arsenopyrite	arsenopyrite	arsenopyrite
galena	galena	galena
pyrite II.	pyrite II.	pyrite II.

The hydropyrite-melnikovite-pyrite II-marcasite-siderite formed from pyrrhotite are identical in Nagybörzsöny and Kisbánya. A common feature of

all three mining districts is that arsenopyrite occurs in an appreciable amount in their lodes. This fact is in contrast with the establishment of Helke, who states that arsenopyrite and arsenic ores in general are very rare in the ore lodes of North-Eastern Roumania and quite unknown in those of North Hungary.

It could be established that arsenopyrite occurs in larger amounts in Nagybörzsöny and Oradna (perhaps even also is Kisbánya) than do the antimony minerals which are usually far more common in hydrothermal ore deposits bound to the tertiär rocks of the Carpathians. Among three mining districts antimonite only occurs in Kisbánya. In Nagybörzsöny and Oradna lead-antimony-sulphides occur only rarely and in small amounts.

As regards bismuth ores Nagybörzsöny differs from the two other mining districts. In the galena of Kisbánya bismuth could only be detected in traces (0,001 per cent), probably it can also only be found in traces in Oradna. As contrasted with these traces the arsenopyrite of our mining district is permeated with bismuth and contains a strikingly large amount of this ore. Another features in which Nagybörzsöny differs from the two others is that its arsenopyrites containing bismuth are also very rich in gold. In Kisbánya the average Au content of the ore is 0,5 g/t, in Oradna it is 0,3—0,2 g/t. The ores of these mining districts are not so rich in gold as are those of Nagybörzsöny (204 g/t). Finally the bismuth tellurides of Nagybörzsöny — known since a long time and now again observed, — and unknown in the other two mining districts, should still be mentioned. Consequently Nagybörzsöny is in every respect the sulphide mining district possessing the most interesting mineral — and element combination. Its element combination — compared with that of the two other mining districts dealt with — can be represented as follows:

Nagybörzsöny:	S	O	Fe	Zn	Pb	Cu	Si	C	Ca	As	Hg	Mn			
Kisbánya:	S	O	Fe	Zn	Pb	Cu	Si	C	Ca	As	Hg	Mn			
Oradna:	S	O	Fe	Zn	Pb	Cu	Si	C	Ca	As	Hg	Mn			
Nagybörzsöny:	Sb	H	Ba	Ag	Bi	Co	F	P	(Cd)	Au	(Ni)	(Te)	(Mo)		
Kisbánya:	Sb	H	Ba	Ag	(Bi)	—	F	P	(Cd)	(Au)	(Ni)	—	—		
Oradna:	Sb	H	Ba	Ag	—	—	F	P	(Cd)	(Au)	—	—	—		

The dominating elements of the mining districts are under lined, the more frequent ones and those which can be demonstrated analytically, dotted whereas the quite rare minor elements which can only be observed spectroscopically are in brackets.

The element association of the three mining districts is also identical, with the exception that bismuth, occurring in significant quantities in Nagybörzsöny and tellure and cobalt detected in traces, cannot be found in the ores of the other two mining districts.

Within the Carpathians range of mountains three hydrothermal occurrences furnish ore containing iron in abundance. They are bound to young tertiär rocks and formed at the highest temperature.

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ИСКОПАЕМЫЕ МЕСТОРОЖДЕНИЯ СЕРНИСТОЙ РУДЫ В НАДЬБЭРЖЕНЬ.

— ШАНДОР КОХ И ЮЛИЙ ГРАССЕЛЛИ —

Хотя в настоящее время в Надьбэржень идёт только разведочная работа, но по обнаруженным ископаемым уже можно установить, что он является самым богатым ископаемыми рудным месторождением Родины, зарождённым при высшей температуре. Рудами и акцессорными минералами его являются:

самые старые минералы — апатит, кварц, пирит I., галенит I., пирротин, валлериит, сфалерит I. (пирротин и халкопирит, с размешиванием), халкопирит (сфалеритными звёздочками);

более молодые минералы, отчасти из материала более старых — арсенопирит, тетраэдрит, висмут, висмутин, золото, галенит II., косамит, сфалерит II., джемсонит, семсеит, тетрадимит, чикловаит, гессит, педзит, аргентит, прустит, молибденит, барит, доламит, калцит;

минералы зоны окисления — гидропирит — мелниковитпирит — пирит II., марказит, сидерит, магнезит, кронштедтит, халкозин, ковеллин, игольчатый железняк, лимонит, арсенит.

Минеральный агрегат его очень близкий к агрегатам месторождений Геря и Родна-Вехе в Румынии, но отличается от этих своими визмутовыми минералами и его арсенопирит — своим содержанием золота.